Making an Anthropocene Ocean: Synoptic Geographies of the International Geophysical Year (1957-1958)

Author: Jessica Lehman[123]

[1] Durham University, Geography
Science Laboratories
South Road
Durham, UK DH1 3LY

[2] University of Minnesota, Department of Geography, Environment and Society
414 Social Sciences
267 19th Ave S.
Minneapolis, MN, USA 55455

[3] University of Cape Town, Marine Research Institute, Department of Oceanography
RW James Building
Upper Campus
Rondebosch
Cape Town, Western Cape, ZA 7701

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Abstract: While the notion of the Anthropocene has generated a great deal of literature across disciplines, the geographic critique of this concept is still developing. This paper contributes to justice-oriented engagements with the Anthropocene by highlighting the relationships through which planetary knowledge is constructed as sites of critique. I develop an analytic of 'synoptic geographies,' which addresses the praxis of coordinated field measurements that creates the planetary knowledge upon which concepts of the

Anthropocene rest. Synoptic geographies require a geographic analytic that is capable of going beyond assertions that all knowledge is local. The International Geophysical Year (1957-1958) provides a strategic opportunity to elaborate the stakes of synoptic geographies. The IGY was arguably the first attempt to understand the Earth as a planet through a program of widespread synoptic data collection. In particular, the synoptic geographies of the IGY's oceanography program reveal the ways in which old and new forms of imperialism were knitted together to produce the world ocean as an object of knowledge in a new era of planet-scale environmental politics.

INTRODUCTION: KNOWING A PLANETARY OCEAN

Welcoming visitors to the Sant Ocean Hall, the Smithsonian Museum of Natural History's largest permanent exhibit, a sign reads: "The ocean is a global system essential to all life – including yours." This is but one example of a view of the ocean, as one dynamic entity with profound significance for life on Earth, that undergirds contemporary understandings of climate change, and even, arguably, 21st century environmental politics writ large. But this ocean is not self-evident or 'natural'; just as no one lives in the global climate, no one directly experiences a global ocean (Edwards 2010). The ocean is local, even intensely so, at every point of embodied experience. Yet it is also increasingly known as global, even planetary, and the ocean's capacity to move, change, and create effects on a planetary scale appears vital to its very nature. Moreover, this planetary notion of the ocean fundamentally underlies the environmental politics of the present.

The idea of the Anthropocene, or even alternatives such as Gaia, fundamentally rests upon the ability to conceptualize the Earth as a planet; to think planetary-scale dynamics and environments; to envision the Earth as one coherent self-regulating system (see Latour 2017; Stengers 2015). For scientists, it is not enough to envision global- or planetary-scale environments; they also must measure and monitor them. This need characterizes the entire complex of Earth System Sciences, including oceanography, glaciology, atmospheric sciences, geology, and even those recently brought under this umbrella, such as ecology. Understanding the geographies brought about by the production of planetary knowledge can further critiques of the Anthropocene. Moreover, geographers ought to pay more attention to the production of planetary knowledge for at least two additional reasons. First, geographers across the discipline are frequently responsible for making global knowledge. Second, as scholars in Science and Technology Studies, and increasingly geography point out, these practices do not just make representations of the world, they make worlds. They put different bodies, technologies, ideologies, and materials into relation and in so doing they create heterogeneous spatialities and sites (Powell 2007). The "data friction" involved in making planetary knowledge sets into motion entire chains of relations and elevates certain sites into positions of prominence in the Anthropocene discourse (Edwards 2010).

This paper develops an analysis of "synoptic geographies," defined as set of coordinated data practices common to many field sciences, and the planetary view that results. The synoptic approach "starts with the observation of data and then continues with the preparation of a concise description, i.e. a 'synopsis'" (Pickard and Emery 1990, 4). Crucially, the emphasis of synoptic sciences, the raw materials with which they draw conclusions, are observational data, today usually gathered by a combination of *in situ* and remote sensors. Synoptic geographies, then, contain elements of the "view from nowhere," as well as grounded attempts to grid and abstract the Earth, although they cannot be reduced to either (see Haraway, 1988, Shapin 1998). Neither conceptual abstraction nor remote technological operation, synoptic geographies operate inductively, linking distant places through careful coordination to produce coherent and quantifiable understandings of the Earth as a planet. While geographers of science have begun to understand the ways in which 'the field' influences science and science influences 'the field' (see Fleming 2014), synoptic geographies thus compel us to ask what happens when 'the field' is not a discrete location but the planet? In considering the specific geographies involved in knowing the planet as such, this paper responds to calls to consider the heterogeneous spatialities of climate change and related dimensions of contemporary environmental politics (e.g. Mahoney and Hulme 2006; Edwards 2010). Moreover, it attempts to demonstrate how a geographic analytic of synoptic geographies can strengthen critiques of the Anthropocene discourse.

This study examines a paradigmatic instance of synoptic science in the practices of the International Geophysical Year (1957-58), a global geophysics program that involved scientists and amateurs from over fifty nations and sought to produce comprehensive knowledge about the whole of the liquid, solid, and gaseous Earth. While the IGY was not the first instance of synoptic science, it "altered the course of science" due not only to the foundational geophysical data collected but also to the paradigm of 'big science' that it initiated (Hampton et al. 2013, 157; Lövbrand, Stripple, and Wiman 2009). The main goal of the IGY was "to collect synoptic data in many fields" (Hamblin 2005, 66). Yet despite its immense influence on many of the sciences (and worldviews) that are most relevant today, the IGY has received little academic attention, and when it is mentioned it tends to be as part of a genealogy of other phenomena; for example, as a key moment in the space race (Launius 2010). In geography, Collis and Dodds (2008) have provided arguably the deepest analysis of the IGY, but their work devotes little attention to the science itself, instead engaging with the legal geographies, science-military relationships, and public media of the project. The IGY deserves geographic attention on these topics, but perhaps even more fundamentally due to its legacies for contemporary environmental epistemologies; it not only hastened the development of every geophysical science involved but also "inspired the build-up of numerical models attempting to capture, on a grand-scale level, basic feedbacks between human society and the global environment," from the pioneering world-systems models of the 1970s to the Earth Systems models of today (Lövbrand, Stripple, and Wiman 2009, 9; Doel 2003).

I focus here particularly on the oceanography program, which exemplified the IGY's guiding aims and principle challenges, and played a significant role in new conceptions of the Earth as characterized by planetary-scale dynamics. Therefore, the IGY oceanography program is more than a convenient example of synoptic geographies. The ocean is increasingly recognized as a key Anthropocene environment. Not only, for example, do Zalasiewicz and colleagues (2008) list ocean changes as key indicators of the Anthropocene, but the ocean has shifted in a range of fields from being understood as a "void to a plenum," now at the center of many of the social and natural processes that define the current era (Oreskes 2014, 384). Geographers, too numerous to cite here, have begun to take renewed interest in the sea (but see for example Anderson and Peters 2014; Steinberg and Peters 2015). Nonetheless, the ways in which we have come to understand this crucial environment have been underexamined in the history of science, much less geography (Oreskes 2014). It remains beyond the scope of this paper to fully detail the developments in oceanography that preceded and developed from the IGY; instead, I focus mainly on the project's two-fold program: a globe-spanning set of oceanographic expeditions, as well as coordinated measurements from a dispersed network of sensors to create the most comprehensive dataset to date on planetary-scale phenomena such as tides, currents, and long waves. It does, however, bear mentioning that specific datasets and technologies developed during the IGY oceanographic program still play important roles in today's evolving understandings of the ocean's role in climate. For example, the float design central to the Argo project, arguably the most important program for ocean climate data, is based on the IGY's Swallow floats (Lehman, 2016). Moreover, as Lövbrand, Stripple, and Wiman assert, IGY data practices "paved the way" for the integrated models that inform contemporary analysis of the feedbacks between ocean, atmosphere, and land at the center of climate science debates (2009, 9).

This paper begins by elucidating some of the stakes of synoptic geographies by linking them to debates about planetary knowledge and politics that have recently emerged in geography, particularly with the advent of the Anthropocene concept. Here, I argue that critiques of the Anthropocene, and even of the planetary, have tended to overlook the processes by which we come to know the planet as such. Moreover, I argue that although the claim common to geographies of science that all scientific practices are always locally situated remains relevant, new strategies are needed to account for the way in which the planet has emerged as an object of scientific knowledge, and consequently governance, for humanity as a whole. I then apply a geographic analytic to the synoptic praxis of the IGY, first by examining the structuring ideology and organization of the project and then delving into the oceanographic program in particular. Specifically, this analysis reveals how the IGY's oceanography program brought together old and new forms of imperialism to produce inductive knowledge about planetary-scale ocean dynamics. The article concludes with some additional thoughts on what a geographic analysis of synoptic science might add to developing critiques of the Anthropocene that highlight justice dimensions.

PLANETARY KNOWLEDGE, SYNOPTIC SCIENCES

A conception of the Earth as a planet fundamentally underlies notions of the Anthropocene. The planet is an integrative concept, bringing together human and nonhuman, biotic, geologic, and social domains, to envision "a single system, comprising a series of 'coupled' 'spheres' characterized by boundaries, tipping points, feedback loops and other forms of nonlinear dynamics" (Lorimer 2017, 119). Thus, planetary thought offers something important to human geographers seeking to move past debates about the nature/culture division. The planetary also reinvigorates macro-scale analysis for the environmental concerns of the 21st century, and arguably after the waning of the concept of the global. As Rowan writes, "[w]hereas 'the global' suggests a relatively flat, anthropocentric conception of the Earth focused on the construction of social relations on the surface, 'the planetary', by contrast, points to a more complex, volumic, stratified understanding of an Earth constituted through dynamic geo-social entanglements" (2014, 447). Like all environmental concepts, the planetary involves specific configurations of both knowledge and power. Litfin describes the planetary as engendering a politics concerned with "a distinctive set of dynamics: complex linkages between the local and the global; the necessity and inherent difficulty of North-South cooperation;

intergenerational time horizons which are typically articulated on the basis of scientific models; a strong tendency towards a holistic understanding of the Earth's systems; and an incremental institutionalization of the precautionary principle" (2008, 470). These dynamics are inseparable from the sciences that facilitate to our capacity to imagine them to begin with.

Earth Systems Science (ESS), a mega-discipline emerging under this name in the 1990s and culminating until now in the Future Earth project, is absolutely essential to Western ideas of the planetary. Hamilton (2016, 94) describes ESS as a "transdisciplinary and holistic approach integrating earth sciences and life sciences, as well as the 'industrial metabolism' of humankind, all within a systems way of thinking, with special focus on the non-linear dynamics of a system." He argues that ESS is truly revolutionary, a "rupture" in thought, and analyses of the Anthropocene that fail to take this into account risk mischaracterizing its significance. ESS has become the dominant paradigm for global environmental change research. It also underlies the extremely influential 'planetary boundaries' agenda, which provisionally defines a "safe operating space for humanity" by identifying "the vital Earth system processes and their dynamic interactions at local, regional and global scales and proposes boundary levels which avoid key tipping points or biophysical thresholds" (Brown 2017, 119-120; see also Rockström et al. 2009). If the Anthropocene authorizes new forms of knowledge, the success of the planetary boundaries framework and related ideas indicates that planetary knowledge is surely at the forefront (Braun 2014).

Geographers have critiqued the implications of ESS and planetary politics more broadly. While the tendencies that Litfin lists for planetary politics seem neutral, perhaps even desirable, Brown (2017) points out that planetary politics are often associated with a kind of top-down global managerialism. Collard, Dempsey, and Sundberg (2015) argue that the emphasis on limits in the planetary boundaries framework is incompatible with indigenous ontologies focused on abundance and flourishing. Perhaps the most pervasive critique of planetary knowledge addresses its scalar ambition, “which erases geographical and cultural difference” and precludes other ways of knowing (Hulme 2010, 559). Castree argues that geographers should put notions such as “assemblage, hybridity, and posthumanism” toward alternatives to global- or planetary-scale knowledge that are more “joined-up” and “actionable” (2015, 310). Similarly, Hulme advocates for a kind of “spectral knowledge” that recognizes multiple understandings of nature and is contextualized, responsive, and accommodating of “ambiguities, voids and blind spots” in contrast to the universal and totalizing tendencies of global or planetary knowledge (2010, 563).

These critiques are of vital importance, and suggest that geographers are aptly situated to produce analyses that at least seriously complicate the “species-thought” toward which the Anthropocene is perhaps inherently inclined, with significant implications for the kind of responses that might be generated (Chakrabarty 2009). And yet despite contributions to broad notions of ‘ways of knowing,’ this literature frequently leaves obscured the very kinds of knowledge that make Anthropocene thought and politics possible; as Castree writes, “relatively few human geographers feel equipped to open the ‘black box’ of environmental science” (2014, 470). Additionally, when human geographers have dedicated attention to the Anthropocene sciences, they have focused mainly on the dating practices of geology, or to some degree on climate science (e.g.

Demerrit 2001). Though of obvious importance, these are only a few components of the scientific practices that allow us to think the Anthropocene. This paper thus seeks to add to constructive critiques of the Anthropocene by inquiring into the conditions of possibility for Anthropocene knowledge, and specifically showing how these knowledges have been shaped by the forces of imperialism during the Cold War, a formative period for the production of planetary thought (Cosgrove 1994).

Human geography is well-positioned to develop critiques of planetary knowledge because the discipline has long paid attention to how scales or references to seemingly natural entities bring together power and knowledge to enable certain politics and foreclose others (see Castree 2014a; 2014b; 2014c; Randalls 2015). The subfield of geographies of science are clearly especially relevant here, as a geographical analysis might show what is at stake in the 'planetary' of planetary knowledge. More specifically, geographies of science may show not simply how science is conducted on a planetary scale, but more importantly how "science itself creates spaces and places for its own activities and in turn spatializes the world in a wide variety of ways" (Naylor 2005, 3; see also Livingstone 1995; Powell 2007). However, synoptic geographies of planetary knowledge suggest a shift in emphasis for most geographies of science. Perhaps the driving motivation for most geographies of science has been "the replacement of the dominant conception of universal rationality with notions of the local geographies of knowledge" (Powell 2007, 319-320; see also Mahoney and Hulme 2016). Indeed, many geographers of science follow Latour's 1987 argument that even universal truth claims can be 'localized' in certain practices that facilitate the mobility, stability, and combinability of knowledge. The 'placelessnes' of universal knowledge emerges from locally-situated practices (Henke and Gieryn 2008). Planetary knowledge is, of course, composed of and given shape by local practices. But it is my contention that without attending to the ways in which synoptic geographies are coordinated on a global scale, we risk missing key dynamics of planetary knowledge. In the case I explore here, these dynamics entail how imperialism, inflected by Cold War geopolitics, has been vital to the production of planetary nature. Thus, the globe or the planet is crucially more than the context in which local practices are carried out (Naylor, 2005). It is also more than that to which data practices must be applied, as Edwards (2010) might suggest. It is itself shaped by the praxis of synoptic science.

The challenge for geographies of science to move beyond the localizing impulse in order to understand the dynamics of planetary knowledge is mirrored, to some degree, in social studies of science more broadly. Some scholars of science and technology have certainly analyzed 'big sciences' such as astronomy, cartography, and big data computing. Nonetheless, the social studies of science that have gained traction, especially across disciplines, have tended to emphasize what Harris (2011) calls 'small science,' typically found in disciplines such as biology, anatomy, and other experimental or lab-based sciences. Here, we can think of the laboratory studies of Latour and others that have been very influential in geography (see for example Latour and Woolgar 1986; Latour 1987; Callon 1984). Harris argues that these narratives of science often emphasize "the work of just a few people working over a short period of time in a restricted geographical setting" (2011, 76). Harris links the tendency to focus on small sciences with popular assertions that all global knowledge can be localized, and with a somewhat ironic tendency of both heterodox and unconventional studies to focus on a limited number of influential technologies, theoretical 'discoveries,' and the "biographies of a handful of great men" (Harris 2011, 77). By contrast, the study of synoptic sciences, which operate in uncontrolled field conditions and entail the labor of many disparate actors, poses methodological challenges similar to those that Harris proposes for the study of 'big science.' How do we employ "both an epistemology and a narrative format capable of moving across scale?" (Harris 2011, 79). How can we grasp the "diffuse discoveries and communal labor characteristic of the big sciences?" (Harris 2011, 80). How can we understand the planetary not as 'placeless' but as a place that emerges from specific scientific practices? (Henke and Gieryn 2008). What form must our analysis take if the 'place' is the planet?

Arguably the most thorough analysis of synoptic geographies to date can be found in the work of Paul Edwards, especially his 2010 study of the history of climate modelling, *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming*. In building an understanding of the knowledge necessary to make claims that the climate is changing, Edwards develops a sophisticated analysis of what he calls "global knowledge infrastructures," and the challenges to creating them, through a historically detailed account of global meteorology. In particular, his sustained attention to what it takes to make global data/make data global, both in everyday praxis and in the creation of lasting systems, greatly informs my efforts here. Where this paper diverges from Edwards' work is not simply in its focus on oceanography rather than meteorology; with a much more limited scope, this article also highlights especially the relationships between emerging planetary knowledge and imperialism that might be elucidated by a geographic analysis of synoptic science. Moreover, while his notions of "making global data" and "making data global" are immediately relevant, I see the globe or the planet not as a pre-given space to be 'filled in' with data but something that emerges from synoptic praxis itself.

In this paper, it will be evident that developing an analytic for synoptic geographies facilitates an analysis of planetary knowledge that might resist the cultures of "scientific heroism" that credit advances to a few charismatic individuals (usually white men) (Oreskes 1996). Further, a geographic analysis of synoptic science might advance postcolonial aims, drawing emphasis away from the established centers of scientific discovery and indicating global dynamics of power and knowledge tightly woven with capitalism and imperialism. As Redfield (2002) argues, a methodological approach that treats all knowledge practices as equally 'local' may miss the politics that make some places and practices not simply appear as 'more' local but also subjects them to the violences of imperialism and colonialism. By analysing the synoptic relations that shaped the IGY, and hence our knowledge of the Earth as a planetary system, I argue that the geopolitical conditions and everyday relations of synoptic science can inform critiques of the Anthropocene that seek not only to unpack its notions of 'nature' but to highlight dimensions of justice and historic processes of imperialism and violence.

PLANETARY KNOWLEDGE AND THE INTERNATIONAL GEOPHYSICAL YEAR

The IGY was catalyzed by both the anxieties and possibilities of the postwar era, from the fears of nuclearism to the potentials of international collaboration in the promised new era of peace and prosperity. Initially conceived as a follow-up to the International Polar Years of 1882-1883 and 1932-1933, the remit of the IGY was soon expanded as "science had raced far ahead with new discoveries, and [these] had spawned scores of complex problems related not to the polar regions alone but to the entire Earth" (Ross 1961, 12). The IGY spanned 18 months, July 1 1957-Dec 31 1958, and involved scientists from 54 nations as well as a cadre of amateurs, all who were "working on the boundaries of their own knowledge of the physical world" (Fraser 1958, xv). The geophysical realms that were explored in the IGY fell into ten categories, encompassing the whole of the liquid, solid, and gaseous Earth: meteorology, oceanography, glaciology, ionospheric physics, the aurora, geomagnetism, cosmic rays, seismology, gravity, and latitudes and longitudes.

The driving impetus of the IGY was data collection, and this focus distinguished it from contemporaneous 'big science' projects, such as the Manhattan Project and the space platforms (Aranova, Baker, and Oreskes 2010). The latter were characterized by "centralized, large-scale scientific research efforts of unprecedented magnitude" while the IGY provided a different model, "distinguished by its emphasis on and the visibility of Big Data—a synoptic collection of observational data on a global geographic scale" (Aronova, Baker, and Oreskes 2010, 185). Although it was perhaps the last international scientific project that was not fundamentally influenced by computational data processing and modeling, the IGY "marked a dramatic transition" to "a more permanent infrastructural globalism" for scientific data (Edwards 2010, 207). Early in the IGY planning process, organizers decided that all data collected was to be freely circulated. As Lövbrand, Stripple, and Wiman write, it was not simply the bird's-eye view of the planet from space that inaugurated views of the Earth as a planet during the IGY, but even more, "[t]he systematic and global-scale collection of geophysical data during this year, and the growing technological capacity of storing and processing such data, paved the way for global biogeochemical and biogeophysical models and their visual representation of an integrated planetary environmental system" (Lövbrand, Stripple, and Wiman 2009, 9).

Three World Data centers were established early in IGY planning: World Data Center A in the United States, World Data Center B in Moscow, and World Data Center C, consisting of subcenters in eight nations in Western Europe, Japan, and Australia. That the World Data Centers fall so neatly along Cold War geopolitical lines certainly suggests a situatedness of IGY data that existed in tension with its claims to globality. Efforts to bring common or unclaimed spaces under territorial and legal jurisdiction, a key outcome of the IGY, hint at some of these tensions. As Collis and Dodds write:

> "On the eve of the IGY, the legal status of the Antarctic, the High Seas, the ocean floors and outer space was legally unfixed and largely undefined. By the 1960s, this had changed. Three landmark treaties were central to this transformation – the 1959 Antarctic Treaty, the 1958 United Nations Conference on the Law of the Sea and the 1967 Outer Space Treaty. The IGY was central to this legal and geographical transformation" (2008, 559).

The influence of the IGY on the governance of these spaces, especially perhaps the poles, is a topic of great interest (see for example Collis and Stevens 2007; Collis 2010; Launius 2010) but here it will have to suffice to say that these agreements, informed by the process of creating synoptic knowledge during the IGY, not only parceled out parts of previously commonly-held spaces for exclusive use by individual nations, they also gave increased authority to intergovernmental agencies. The move toward international governance is a hallmark of linked legal and ecological management in the Anthropocene, as well as a key feature of the broader turn to planetary politics (e.g. Litfin 2008; Lövbrand, Stripple, and Wiman 2009). This shift should be understood as perhaps one of the most influential outcomes of Cold War synoptic geographies.

The IGY's synoptic geographies were tightly tied to certain imaginaries of the Earth, and the program thus played a significant role in defining new strategies and goals for governance (Lövbrand, Stripple, and Wiman 2009). Perhaps more precisely, synoptic science during the IGY, and the methods by which it was produced, both fit into and influenced Cold War internationalism and its legacies; Doel goes so far as to call the IGY "the development that most illustrated the link between geophysics and the power of the state" (2003, 647). There is, of course, much to say about science, spatiality, and internationalism in the Cold War, most of it beyond the scope of this paper (see instead Hamblin 2005; Barnes and Farish 2008; Farish 2010; Edwards 2010; Mirowski 2002). Farish (2010) argues that the Cold War should be understood spatially, not just historically. He shows how the scales of globe, region, continent, and city were given collective and strategic definition not simply through conflict between global superpowers but also in the less binarized, more complex geopolitics of the era. When it comes to science specifically, East-West tensions, especially between the US and Russia, "stimulated public patronage for research that was sustained and massive," and ideological battles and military interests certainly shaped science at many scales (Solovey 2001, 165). Yet as Edwards (2010) stresses, scientific internationalism during the Cold War was not simply a cover for nationalistic strategy. As he writes, "as a contest between ideologies and social systems, the Cold War demanded that nations prove their commitments to peace, scientific progress, and the improvement of everyday life" (2010, 224). For scientists, transcending national borders was nothing new, though many such endeavors had been interrupted by World War II. In the postwar period, many "simply wanted to continue their traditional internationalism and openness" (Edwards 2010, 224;

see also Hamblin 2005). Cosgrove, following Tenbruch, uses the term “one-worldism” to describe some of these tensions (1994). For Cosgrove, the turn to images of the globe and notions of universal human benefit are expressions of a postwar form of American imperialism, which emphasizes “spatial and social *incorporation* rather [than] direct imperial domination” (Cosgrove 1994, 281). Ideas of global harmony and the pursuit of universal planetary knowledge, propagated by the US but also by US-led institutions like the United Nations, carried a thinly veiled assumption that the United States would be the technical and political leader of such a world, counter-posed to Soviet territoriality. IGY literature clearly aligns with this ideology, positing the program as a kind of post-political exploration, a sort of adventure not for political but for scientific ends. President Eisenhower’s words at the start of the IGY reflect as much: “As I see it, [...] the most important result of the International Geophysical Year is the demonstration of the ability of peoples of all nations to work together harmoniously for the common good. I hope this can become common practice in other forms of human endeavor.”[1] Science writer Ronald Fraser puts it thus:

> “The high aim of the IGY effort, in short, is not technical but scientific. It is the first concerted world-wide attack by man on the mysteries of his own environment. It would be surprising if it were the last. This key feature of the enterprise cannot be emphasized too strongly. The urge which has led scientists of 54 nations to install their instruments on ice floes in the Arctic, on remote islands in the Pacific, on high peaks in the Andes, in the frozen wastes of Antarctica, is not an urge to discover new lands, or to blaze new geographical trails. It is an urge to a new kind of adventure - the scientific exploration of the earth as a planet” (Fraser 1958, 24).

[1] Remarks by the president in connection with the opening of the International Geophysical Year; International Geophysical Year 6/30/57; Dwight. D. Eisenhower National Archive, Abilene, KS.

This planetary-view discourse takes visual form in Figure 1, showing US IGY committee chairman gazing at a transparent model of the planet and its environment.

Resonating strongly with one-worldism, an emphasis on studying the Earth as a planet was the code of entry and ultimate signature of the IGY. To participate in IGY, national programs had to show that their efforts were aimed at understanding the Earth as a planet: “In a sense, the IGY was a scientific club. To gain admittance - that is, to be included in the IGY program - a scientific project had to be concerned with 'specific planetary problems of the earth'” (Sullivan 1959). As the Canadian geophysicist J. Tuzo Wilson put it, one of the IGY’s principle achievements was “the transformation of earth science into planetary science” (Wilson 1961, 320). In another example, Ross states that among IGY’s distinctive features, “first and foremost was the fact that it used the earth and the enveloping world of space as a gigantic laboratory. These areas, together with the sun, were observed and studied as never before by scientists working on an international co-operative basis” (Ross 1961, 7).

Language of one-worldism occluded not only Cold War tensions but also other inequalities in IGY participation. While literature on the participation of the colonized and decolonizing world is scant, one report, titled “The International Geophysical Year in Africa South of the Sahara,” prepared by S.P. Jackson, the “Interafrican Scientific Correspondent for Climatology,” provides a small window into IGY activities in the colonized world.[2] Jackson evaluates the IGY plans of various countries by grouping them by their colonial overseers. He writes that while “the French and Belgian

[2] Jackson, S.P. The International Geophysical Year in Africa South of the Sahara. Commission for Technical Co-operation in Africa South of the Sahara. National Library of South Africa.

programmes in Africa have been carefully planned and adequately financed," the story in the British territories is different: "there were strong expressions of frustration and disappointment - no additional funds have been voted for even relatively inexpensive equipment and the costs of participation in the programme of the International Geophysical Year will have to be met out of already overstrained budgets for ordinary work."[3] Moreover, he writes, the arrangement of the IGY programs in Africa "has some disadvantages from the point of view of African science; there has been very little discussion of plans between neighbouring territories and no co-ordination except in the field of meteorology." As for meteorology, Edwards writes that decolonization that was occurring concurrently with the IGY "created a crisis for data collection as meteorological services once supported by far-flung colonial empires fell under the precarious management of emerging nations much less committed to the project of infrastructural globalism" (2010, 206).

If Jackson's report indicates some of the general woes of IGY research in the global South, then the oceanography program provides a more precise bellwether. Although 36 nations participated in IGY oceanographic research, only three of these were African nations (compared with six South/Central American, seven Asian, 15 European, as well as the US, Australia, Canada, New Zealand, and the USSR). Moreover, South Africa, which, though still under Apartheid rule, had become independent from the United Kingdom 20 years prior, was the only African nation to have a program that involved research cruises as opposed to simply the maintenance of tide and sea-level gauges.

[3] Ibid., 3.

Already we can see that synoptic geographies entail not just uneven data coverage of the globe, but also unequal geopolitical relationships, serving to further scientific expertise and in some geographic areas and not others while at the same time creating a notion of the planet as an object of knowledge for all of humanity. But to more deeply understand how imperial relations and social difference were elided in producing a global environment, we must look in greater detail at the coordinated measurements that comprised the oceanographic program of the IGY. Through this examination we can see how geopolitical and imperial power is expressed in, and emerges from, these synoptic geographies.

A PLANETARY SEA: THE IGY OCEANOGRAPHIC PROGRAM

The IGY oceanographic program consisted of two main elements: the study of ocean circulation, especially of deep-sea currents, and the measurement of changes in sea level and ocean waves. Currents, of course, had been observed throughout the history of human engagement with the sea. Scientists knew that they were caused by surface winds as well as by the shape of ocean basins, the rotation of the Earth, and differentials in temperature and salinity that cause water masses to sink in some places and float to the surface in others. Yet, as I discuss further below, the particular mechanisms by which these currents function remained unknown, much less quantified. This was certainly not simply an academic question; not only do currents affect marine navigation, but they also are relevant to environmental concerns that were imminent to the time, such as the disposal of nuclear waste, the ocean's role in climate, and the potential of marine protein to feed growing populations. Thus synoptic geographies were called upon to address anxieties of socio-environmental catastrophes that transcend territorial and temporal borders; anxieties that link Cold War internationalism to the planetary politics of the present.

The second part of the IGY oceanography program sought to solve some mysteries regarding variations in sea level over both short and long timespans. In particular, scientists were interested in explaining seasonal change in sea level, and understanding whether observed changes were consistent from place to place. They also sought to understand "long waves which travel the whole width of the oceans" (Laclavère 1960, 176). The executive committee for oceanography describes this puzzle in the *Annals of the IGY*: "It is well known that there are many kinds of surface oscillations longer than ordinary waves and shorter than the main tidal periods, but little is known about their propagation in deep water" (Laclavère 1960, 176). These waves were thought to be generated from weather events and pressure changes as well as seismic events, as in the case of tsunami waves, and studying them had potential impacts for weather forecasting, disaster planning, and coastal infrastructure (Deacon 1957).

The two parts of the IGY oceanography program, ocean circulation and sea level and long wave recording, entailed two very different sets of methodologies, which enrolled different actors and had different sets of challenges (see also Hamblin 2005). The program to study ocean circulation consisted almost entirely of measurements taken during highly coordinated oceanographic research cruises. At "intervals during the course of a voyage," measurements were taken, most frequently "those termed 'serial observations,' which provide data on a variety of elements (temperature, salinity, dissolved gases, and others) at different levels between the surface and the bottom of the sea" (Lumby 1960, 1). Measurements and observations on a number of other topics were also recorded on these cruises, including water color and transparency, “state of the sea and swell,” bathymetry, and biology (Special Committee for the IGY 1959, 298). Two new technologies also aided the study of ocean circulation. The bathythermograph (Figure 2), developed in the US to aid in WWII submarine warfare, allowed measurements of temperature variation with depth to be easily taken from moving ships (see Oreskes 2000 for a detailed analysis of the politics of bathythermograph measurements).

Another important technology was the neutrally buoyant float, invented in the UK, which allowed for currents to be tracked at different depths (Figure 3). The floats were designed to sink to certain depths and contained a sonar ‘ping’ that could be detected from listening ships on the surface. These technologies, in addition to previously existing methods, allowed scientists to sample the sea at regular intervals and to generate an unprecedented amount of oceanographic data, even though most of the sea remained un-sampled. The coordinated nature of the cruises allowed, for example, for scientists to confirm the presence of a deep current below the Gulf Stream, running in the counter direction along North America’s East Coast. Furthermore, both the bathythermograph and the neutrally buoyant float have enduring legacies. While the bathythermograph is used today in a similar form, neutrally-buoyant floats have undergone several stages of innovation which now allow them to be highly programmable, to collect data such as temperature, salinity, and dissolved oxygen at various depths, and to be tracked via satellite (see also Author, 2016; 2017). They are a key synoptic technology of Anthropocene ocean knowledge.

The reliance on oceanographic research cruises for the circulation studies of the IGY hence extended the tradition of blending oceanographic science with sea-faring adventure and exploration. The IGY study of ocean circulation was executed through a number of coordinated cruises carried out by 70 ships from 35 nations (Schlee 1973, 346). Yet, the US and UK conducted the lion's share, along with the USSR. Other wealthy nations with traditions of seafaring also participated, including Germany, France, and Norway. Navies still funded much of this research; in the US, the national committee for the IGY suggested that the Office for Naval Research (ONR) take control of the IGY program because "the ONR has had a long and successful history in organizing and managing an effective oceanographic program."[4] Participation in the IGY was a way for oceanographers in these military superpowers to show the relevance of their discipline beyond its wartime applications, thus ensuring continued governmental and public support. At the same time, oceanography continued to be highly relevant to imperial militaries, even as these forces were themselves adapting to the Cold War contexts. Fraser's words exemplify the intersections between military and peacetime concerns in the nuclear era, expressed through marine materialities:

> "the age of the atomic energy power station is already upon us, and we must ask ourselves betimes whether it is really sensible to use the ocean floor as a dump for radio-active waste. If the turnover of the ocean waters is too slow, we may soon poison large areas of the sea; if fast enough, then the dispersion of the radio-active waste might be so complete as to be harmless, even in the face of the incredible power of living organisms to concentrate minute traces of rare elements in their own blood and tissue" (Fraser 1958,7; see also Hamblin 2005; 2006).

[4] Minutes of Fifth Meeting, USNC Executive Committee March 8, 1955 Washington DC. In File: International Geophysical Year U.S. National Committee Meetings - 1955, National Archives at College Park, College Park, MD.

Efforts to cement the centrality of oceanography to emerging national concerns were largely successful; following the IGY, both the US and UK saw significant investment in oceanography. This was evidenced most immediately in support for the Indian Ocean Expedition that immediately followed, and the International Decade of Ocean Exploration that began in 1969.

While oceanography adopted a prominent position in the emerging Cold War context, its agents also inspired affective connections with older agents of empire: masculine sailors aboard long-distance vessels. Walter Sullivan, the *New York Times* full-time reporter for the IGY, was quick to equate the physical presence of American scientists with their ability to make oceanographic knowledge, for example describing Roger Revelle as "an enormous man (6ft 4 in) who looks as if he were specially designed, both physically and temperamentally, to study the Pacific Ocean" (Sullivan 1961, 346). In fact, Sullivan's words indicate the way that oceanographic cruises during the IGY carried on legacies of exploration and adventure, despite assertions of international cooperation and a new era of scientific exploration:

> "These men, accustomed to living with salt in their hair and their lives in jeopardy, typify oceanography as it was in the United States at the start of the IGY - a science pursued by barefoot youths in ragged shorts and greasy shirts on the wave-swept decks of sailing ships. What a contrast to the surroundings of other IGY explorers - the men on the launching pads at Cape Canaveral, or those with their instruments mounted in multi jet aircraft!" (Sullivan 1961, 346).

This discussion of the ship-based ocean circulation research during the IGY provides some insight into how the long networks of oceanography as a planetary science built upon imperial legacies and geopolitical tensions to catalyze new ideas of the Earth as a planet. However, this account risks remaining focused on a few ships, a select number of scientists, and a set of key technological developments; the hallmarks of what Harris

(2011) characterizes as ‘small science’ analysis. Truly accounting for the synoptic relations of IGY oceanography entails examining the relations that are occluded in most accounts of oceanographic expeditions, which are only part of the distinctive, dispersed, and heterogeneous processes by which synoptic science gets made. For example, Oreskes (2000) has written about the gendered nature of oceanographic labor during the post-war period, analyzing the crucial yet underrecognized women’s work of compiling bathythermograph records. In addition to women data-processors, attention is due to the perhaps less exciting work of recording sea levels and long waves, to which I now turn in greater detail. Because the long wave study involved new research, while the sea level studies primarily involved the coordination of routinely captured data, I focus on the former here. This crucial work was not performed by prestigious scientists working from centers of expertise but by technicians, natural resource managers, lighthouse keepers, and others on remote islands and colonial coasts.

LONG WAVE RECORDERS AND IGY GLOBALITY

The technologies by which long waves were recorded during the IGY provide an entry point into the midcentury politics of synoptic oceanography. Rather than being measured using instruments deployed from ships on high-seas missions, sea level and long waves were mostly measured using gauges or recorders installed in ports, on reefs, or on other coastal infrastructures. Recording long waves, in particular, presented some challenges. Ideally, long wave recorders should be set up away from the influence of coasts and coastal infrastructures, which interfere with the propagation and travel of the waves (Van Dorn and Donn 1969). Yet, the recorders of the 1950s (seen in Figure 4) needed to be attached to rigid frames (contemporary versions are now usually attached to buoys, or measure pressure and depth variations in the water column from the sea floor). Therefore, IGY scientists determined that “the most practical compromise so far employed is the installation of special recorders on small, isolated Pacific Islands, with the detector located on a steep offshore slope” (Van Dorn and Donn 1969, 47).

By locating wave recorders on remote islands, the IGY enrolled a set of actors distinct from the intrepid high-seas scientists from major research centers. The labor of local technicians and resource managers was required to keep the gauges in working order as well as to collect and report the data; for example, South Africa’s IGY plans included the suggestion that “the light house keepers at Dassen and Bird Islands respectively be paid an honorarium of 5 pounds per month […] to look after the equipment after it had been installed and to change the recorder paper, etc.”[5] Not only were places that previously had little contact with imperial oceanography included; they were specifically targeted: “Cooperation [was] solicited from countries bordering on oceanic areas where specific gaps existed in the network of stations previously proposed, such as, the South Atlantic and Indian Oceans” (Van Dorn and Donn 1969, 49).

Discussion of the wave recorder and sea level programs of the IGY break with the usual narrative tropes of IGY reporting and provide a rare opportunity to view the IGY as something other than an unqualified success. Though it is still steeped in pervasive IGY optimism, one report on the long wave recorder program does more than hint at trouble:

[5] Program Report, South Africa National Committee for the International Geophysical Year 1957-58, Third Assembly of the Special Committee for the International Geophysical Year (CSAGI) 1957-1958, Brussels, September 1955. In RG 59 General Records of the Department of State, Records Relating to International Conferences, 1949-1958, and to the International Geophysical Year 1954-1958 (Multiple Lots) (Lot) 61D333 S/Sa Box 9 NN3-89-15, National Archives at College Park, College Park, MD.

"It is doubtful whether the study of long waves is entirely successful. It is a new venture and there was insufficient time to gain experience with the apparatus designed for the purpose" (Laclavère 1960, 177). It is difficult to obtain information on the day-to-day work of the long wave and sea level programs; human operators of the wave recorders are rarely mentioned in IGY primary documents or the scientific articles that resulted. But some statements indicate that not all went smoothly; for example, Van Dorn, the inventor of the most prominent IGY long wave recorder, wrote that the instruments were "susceptible to storm damage and local vandalism" (Van Dorn 1960, 1012).

Why would local residents vandalize long wave recorders? Justification for this statement is lacking here, but we can imagine why tensions might exist. The imperial legacies of oceanography are not limited to the trope of adventuring sailor. The recording of long waves is also directly tied to US imperialism, albeit in more modern forms. The first long wave recorders were established near the Scripps Institute for Oceanography in La Jolla, CA in 1947 and 1948. However, their development was slow and "analysis of these records failed to produce any consistent cause and effect relationship" (Van Dorn and Donn 1969, 48). Then, in 1952, oceanographers were invited to make long wave measurements during the US's first thermo-nuclear weapons test in the Bikini Atoll. The recorders used during this expedition were "hastily improvised and crudely designed," but opportunities to improve them were proffered by more nuclear tests in 1954 and 1956, leading the developers of the recording device used during IGY to conclude that "while most of these studies remain unclassified, it can be stated that coherent crest arrivals were observed at all stations, and consistent empirical relationships have been derived from these data which have materially improved our understanding of the generation and propagation of long waves in the open sea" (Van Dorn and Donn 1960, 49). The US Pacific nuclear tests did not simply provide an invaluable opportunity for the testing and development of technologies. They also informed the scientists' decision to install the long wave recorders on isolated Pacific islands, chosen ostensibly because of the high incidence of tsunamis nearby but surely aided by the scientists' past experience in the region.

The IGY long wave program followed closely in the footsteps of the nuclear tests. Again, oceanographers from SIO developed instruments to be used (manufactured by Non-Linear Systems in nearby Del Mar, CA), and "personally visited Chile, Peru, New Zealand, Tahiti, and Japan to instruct local scientists in the operation of the instruments and, where possible, to assist them in site location and installation" (Van Dorn and Donn 1969, 49). US IGY long wave stations were also located on Pacific islands (Wake, Johnston, Canton) that were administered by the US Department of Defense (and some continue to host military installations and their toxic legacies) (Van Dorn and Donn, 1969). Sometimes local fisheries managers, light house keepers, and others managed long wave and sea level data collection, but at other times these roles were executed under the purview of the US military.

The design of the long wave and sea level programs, their associated technologies, and their roots in nuclear experimentation introduce networks of relation that emphasis on the ship-based study of ocean circulation misses. The legacy of long wave recorders in nuclear experimentation indicates another globality that is indelibly entangled with the IGY's storied globality of international cooperation, scientific diplomacy, and collaborative quest to solve the planet's mysteries. As several have argued, a globality of nuclearism underlies a globality of international unity; perhaps in fact "the planetary extent of this militarized radiation inspired the modern concept of globalism itself" (Deloughrey 2012, 168). Deloughrey argues that the myth of island isolation resides at the heart of Cold War science, linking the atom bomb tests with the emergent study of ecosystems (another key component of Anthropocene knowledge). The connection between nuclear testing and long wave recorders, and their installment on 'isolated' islands during the IGY, shows similar dynamics. On one hand, the isolation of the islands was understood as important for studying long waves unfettered by the influence of other landmasses. On the other hand, the long wave program was designed to reduce the islands' isolation, bringing them into networks of measurement by both covering previous gaps in global measurements and establishing new research stations by installing equipment and training local technicians. Thus, attention to the synoptic geographies of the IGY oceanography program reveals how contemporary understandings of the ocean as a planetary entity emerged from and contributed to the complex networks of experimentation, nuclearism, militarism, and resistance that continue to shape the Pacific (see for example Davis 2014). More broadly, in making global knowledge about the propagation of long waves in the sea, the IGY's oceanography program knitted together old and new forms of imperialism in constructing the world ocean as an object of knowledge in a new era of planet-scale environmental politics.

CONCLUSION: SYNOPTIC GEOGRAPHIES AND THE ANTHROPOCENE CRITIQUE

This paper has both argued for the development of a geographic analytic of synoptic geographies, and, through an exploration of the IGY oceanography program, demonstrated what such an analytic might reveal. Synoptic geographies create certain visions of the planet; visions that are not strictly views from above nor from below; neither from nowhere nor everywhere. Moreover, synoptic geographies are inductive practices rather than conceptual abstractions. Synoptic geographies, through a set of emplaced measurements coordinated across time and space, bring into view the very 'nature' that provides and defines the conditions of possibility for Anthropocene environmental politics. It is only through these practices that we are able to understand the Earth as a planet, and understand its capacities for change as governed by planetary-scale systems dynamics. As world-making practices, synoptic geographies also elevate certain places, in this case remote Pacific islands, to global status (Camprubí 2018). A critical analysis of synoptic geographies shows that Anthropocene knowledge is not just located in the meetings of the International Stratigraphic Society. And yet, as this analysis has shown, what synoptic geographies hide from view is just as important as what they reveal. Read uncritically, in producing a planetary nature that is cohesive, self-regulated, and totalizing, synoptic geographies "occlude [their] infrastructural history and conditions of possibility" (Helmreich 2011, 1211). As the case of global oceanography shows, in obscuring the social and material infrastructures that make planetary views possible, synoptic geographies hide the international division of scientific labor, and moreover, the ways in which planetary knowledge is intertwined with the dynamics of imperialism. Synoptic geographies also hide the contingency of their planetary views. A geographic analytic shows that notions of the Earth as a planet upon which the

Anthropocene depends are self-evident reflections of reality but emerge only out of a set of geopolitical and technical relations. While it may not be revelatory to state that the Earth of the Anthropocene is a distinctly social entity, this exploration of the IGY shows that this declaration is insufficient on its own. Rather, to fully account for difference and violence in the Anthropocene we must pay close attention to the particular synoptic geographies through which the Anthropocene Earth (and ocean) have come to be known.

In his analysis of the synoptic geographies of climate modeling, Edwards details what he calls metadata friction: "the labor of recovering data's context of creation, restoring the memory of how those numbers were made" (2010, 432). Grappling with metadata friction is one of the necessary tasks for scientists to learn new things from old data, something they must continue to pursue if they wish to understand how the climate is changing over time. Geographers who engage with the environmental politics of the Anthropocene have their own metadata friction to contend with, regarding the ways in which planetary environments have come to be understood. Considering synoptic geographies from this standpoint, we might not only learn from the data they produced but also learn how to be socially and politically accountable to and for the worlds that their praxis has created.

To take this assertion further, if scientists must contend with metadata friction in order to make reliable knowledge, then for geographers this pursuit is not simply about the ability to create facts but to fully elaborate the justice dimensions of the Anthropocene critique. Although it has generated a great deal of literature, the Anthropocene is still a new concept. It is not only new but also extremely broad in scope and in potential for unsettling thought (and perhaps, ultimately, politics). As such, the geographic critique of the Anthropocene is still being worked out. While it seems that this critique must necessarily be concerned with justice and difference, so far this effort has been incomplete. To use broad strokes: efforts to think difference, violence and inequality have focused on the creation of the conditions of the Anthropocene on one hand and its effects on the other. By now it is widely acknowledged that the Anthropocene was born out of the violences of slavery, colonization, dispossession, and imperialism, regardless of the start date hypothesis to which one ascribes (see for example Moore 2017 on the Capitalocene; Haraway 2015 on the Plantationocene; and Vergès 2017 on the Racial Capitalocene). Another body of scholarship, too large to cite fully here, focuses on the unequal impacts of environmental degradation and climate change; tying these two bodies of scholarship together, perhaps, is the adage that those who have contributed the least to climate change and other environmental woes will bear the brunt of these effects.

While these arguments are absolutely vital, this paper locates another source for an emerging justice critique of the Anthropocene: the scientific knowledge processes upon which ideas of the Anthropocene depend. For example, Ghosh (2016) has argued that imperialism was just as influential as capitalism in determining the conditions of the Anthropocene. My exploration of the IGY's oceanography program shows that imperialism has also shaped the ways in which Anthropocene natures have come to be known. By studying synoptic geographies as globally-coordinated situated practices, we can see how the emergence of the planetary as an object of knowledge depends on imperial networks refracted through the politics of the Cold War. Thus certain places, people, and practices become evident as sites for further critique of (in)justice in the

Anthropocene. It is not enough to simply say that synoptic science is composed of complex relations, nor that global knowledge elides difference in the production of powerful universalisms. Rather, synoptic geographies compel us to deeper understandings of how complexities and differences *matter*, impacting how problems and possibilities are framed in contemporary environmental politics. Ultimately, it is nature itself that is at stake in these epistemologies of the Anthropocene. The world we have to work on, to live in, to be responsible for, can and should only be understood as a product of the relations that make it legible.

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Author biography: Jessica Lehman is an Assistant Professor of Geography (Human-Environment) in the Department of Geography at Durham University, Durham DH1 3LY, UK. Email: Jessica.lehman@durham.ac.uk. Her research interests include international environmental politics, science and technology studies, marine geographies, and resource politics.

Figure captions:

Fig. 1. Joseph Kaplan, chairman of the US National Committee for the IGY, looks at a transparent globe of the planet and its surrounds. Source: Special Packet: The United States and the International Geophysical Year, U.S. Information Agency, 1957. National Archives at College Park, College Park, MD.

Fig. 2. A scientist prepares to deploy a bathythermograph during the IGY. Source: Odishaw, H. 1958. The International Geophysical Year. *Science 288*(3339):37. Image reproduced with permission.

Fig. 3. John Swallow works on the neutrally-buoyant float that he is credited with inventing shortly before the start of the IGY. Source: National Oceanographic Library, Archives. National Oceanography Centre, Southampton. Image reproduced with permission.

Fig. 4. A Van Dorn long wave recorder, a slight variation on the main design used during the IGY. Source: Van Dorn, W. 1960. A New Long-Period Wave Recorder. *Journal of Geophysical Research 65*(3):1010. Image reproduced with permission.